Progress Report
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CARDIOPULMONARY TOXICITY INDUCED BY AMBIENT PARTICULATE MATTER
(TRI CITY CONCENTRATED AMBIENT PARTICLE STUDY)

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DISCLAIMER

EXECUTIVE SUMMARY

The Tri City Concentrated Ambient Particle Study (Tri City CAPS) is designed to investigate the sources and components of fine particulate matter ($PM_{2.5}$) responsible for adverse health effects, with an emphasis on coal-fired power plant-derived PM. The Project is a multi-site field study to investigate the toxicity of secondary $PM_{2.5}$ derived from coal-fired power plants and other sources, including mobile sources. A portable ambient particle concentrator coupled with a mobile toxicological laboratory are employed to assess the health effects of CAPs in regions dominated by different PM sources. The Project includes three study locations, each to be evaluated during both winter and summer seasons to exploit different meteorological regimes. The first study location is located near the Ambassador Bridge in Detroit, MI, and is heavily influenced by both idling diesel truck traffic and gasoline-fueled commuter traffic. This site also corresponds to the location of an EPRI-funded air pollution epidemiology study. The second site is located in Steubenville, OH, an area dominated by both regional power plant-derived PM as well as local industrial sources. The third site is located in Maurice K. Goddard State Park in Northwest Pennsylvania, an area also heavily influenced by power plant emissions, but lacking urban or industrial influences. The selection of sites and seasons is based on achieving the highest degree of variability in PM composition and contribution from different sources. Spontaneously hypertensive (SH) and normal (Wistar-Kyoto) rats are exposed to CAPs from these locations for 13 consecutive days and assessed for a wide suite of cardiopulmonary endpoints. The rats are implanted with telemeters and evaluated for pulmonary, systemic, and cardiovascular effects. At the same time, comprehensive exposure characterization is carried out to enable linking of adverse health impacts with PM composition. Also, importantly, source apportionment is carried out to enable attribution of toxicological effects to specific PM sources.

This report documents progress made on the Project during the period of April 1, 2006 through June 30, 2006. During this reporting period, laboratory chemical analyses and biological assays were continued on CAPs and $PM_{2.5}$ samples collected during the first and second rounds of fieldwork (Detroit; July 16-28 and February 11-23, respectively). In particular, semi-continuous elemental data from the slurry sampler are now available for Season 1. Processing and data interpretation of cardiac function and other toxicological data collected in Seasons 1 and 2 are continuing.

During the next reporting period, exposure and toxicological analyses for Site 1 (both seasons) will continue. Site 2, Season 2 fieldwork is scheduled for August 2 – 14, 2006 in Steubenville, OH; the original exposure dates were July 27 – August 9, but difficulty in procuring copper wire resulted in a delay.

PROJECT PROGRESS

Approach

The monitoring location for the work described in this report is Maybury Elementary School, located at 4410 Porter St. in Southwest Detroit. This site is located ½ mile from the Ambassador Bridge, the busiest border crossing between Canada and the United States with daily traffic volume near this site estimated to be as high as 100,000 vehicles/day. Major contributors to the local traffic congestion are diesel trucks involved in import-export trade, and with materials delivery to and from auto and manufacturing industries in Detroit. Thus, PM at the site is heavily dominated by diesel emission-derived particles. The site is also located 1 block from Interstate 75, the primary southbound route from Detroit to Ohio, thereby contributing gasoline emission-derived PM to exposures conducted at this location.

The Ambassador Bridge area is also being studied as part of the Detroit Exposure and Aerosol Research Study (DEARS), a large EPA-funded exposure assessment study to investigate the importance of different PM sources to residential and personal exposures. DEARS specifically targets the Ambassador Bridge site as being a location heavily impacted by mobile sources. Coupled with DEARS is the EPRI-funded Detroit Cardiovascular Health Study, an epidemiological panel study to be conducted in the same cohort as the exposure study, and at the same time as the proposed Project. Thus, the Project will integrate the toxicology, epidemiology and exposure assessment disciplines for the same site.

Objectives

The primary objective of the Project is to evaluate the potential for adverse cardiopulmonary effects from ambient exposure to realistic (environmentally relevant) coal-fired power plant and traffic-related PM. Secondary objectives of the study are to (1) provide insight into toxicological mechanisms of PM-induced cardiopulmonary effects, particularly as they relate to susceptible subpopulations; and (2) generate toxicological data to directly correspond to epidemiology and exposure assessment data from concurrent studies being conducted at one of the Project locations, providing a rich dataset of human and animal data exploring the associations between PM sources and components and health.

Results and Discussion

There are some new exposure data in this progress report, including slurry sampling results from Site 1, Season 1 and preliminary source apportionment results.

Site 1, Season 1

Exposure Results

Trace element analysis of slurry samples collected from the Semi-Continuous Elements in Aerosol System (SEAS), including quality assurance (QA) and quality control (QC), was completed. A suite of trace elements was quantified semi-continuously (every 30 minutes) for

the daily exposure period. Trace element concentrations associated with fine fraction aerosols during the eight-hour exposure periods on the 18th and 20th of July were plotted.

On the 18th of July, the average concentrations of both CAPs and ambient $PM_{2.5}$ were the highest among the 13 eight-hour exposure periods. Figure 1 shows the temporal concentrations of cadmium (Cd), lead (Pb), iron (Fe), sulfur (S), zinc (Zn) and rubidium (Rb). In the morning, local combustion sources including incinerators and iron/steel industries as well as vehicle traffic appeared to have made significant contributions to ambient $PM_{2.5}$ in SW Detroit. The dominant wind direction during the morning exposure period was consistently from the southwest, where the major industrial activity is located in the city. In the afternoon, the dominant wind direction shifted from southwest to south, and a significant impact from transported, secondary aerosols was observed as indicated by episodic increases in sulfur/sulfates. Hybrid Single-Particle Lagrangian Integrated Trajectory model (HYSPLIT4) will be used to calculate backward air mass trajectories to further investigate transported aerosols.

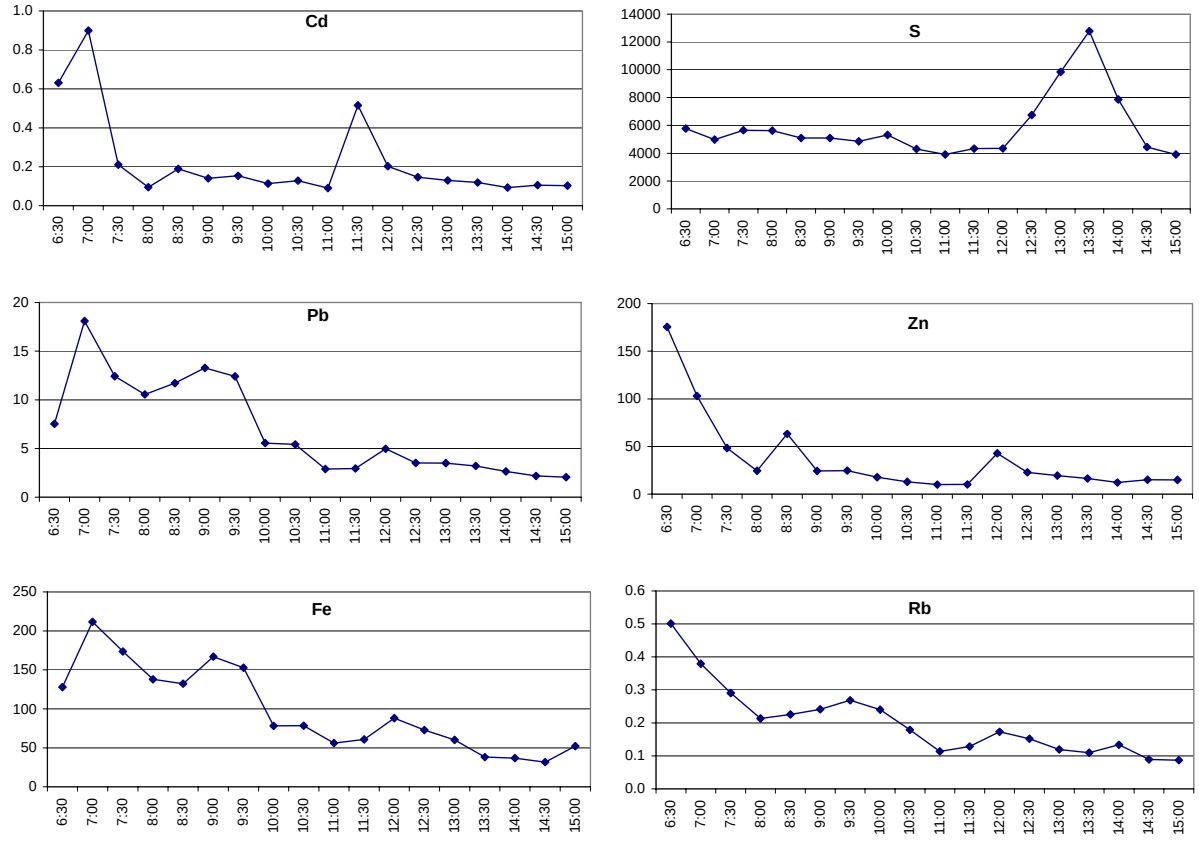

Figure 1. Temporal variations in anthropogenic metal and element concentrations collected by the SEAS on July 18th, 2005.

Figure 2 shows the measured, temporal variations in the concentrations of cadmium (Cd), lead (Pb), zinc (Zn), sulfur (S), selenium (Se) and antimony (Sb) on the 20 July. The average concentration of elemental carbon in both CAPs and ambient $PM_{2.5}$ was the highest among the 13

eight-hour exposure periods. As seen in the figure, the levels of Cd, Pb, Sb, and Zn were elevated during the early morning.

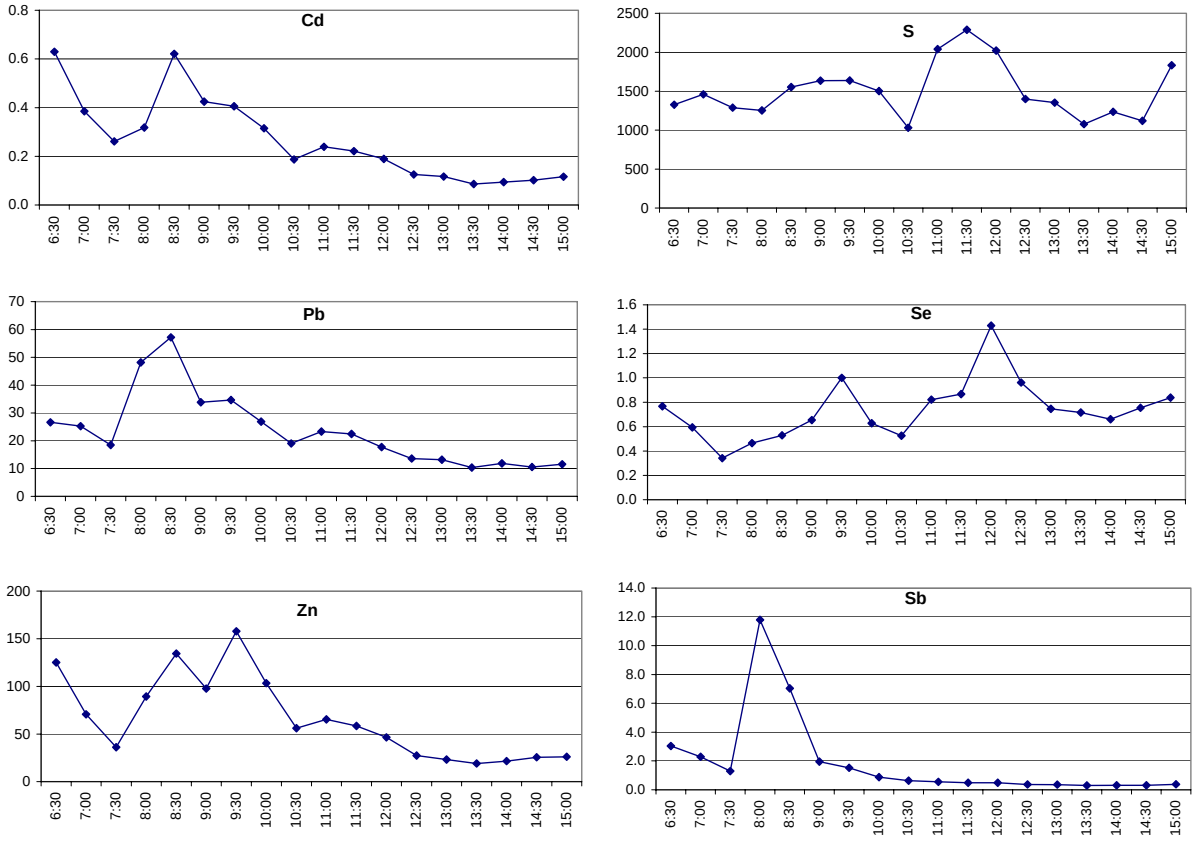

Figure 2. Temporal variations in anthropogenic metal and element concentrations collected by the SEAS on July 20th, 2005.

A preliminary analysis revealed that northerly winds may have brought a plume from a local municipal incinerator as well as emissions from the heavy traffic. By late morning, the dominant wind direction shifted to southwest and elevated levels of S and Se were observed. In addition, the average concentration of sulfur dioxide on the 20th was the highest among the 13 eight-hour exposure periods. This suggests that the site may have been impacted by local coal combustion sources.

Furthermore, the Positive Matrix Factorization (PMF) receptor model has been used to determine the major emission sources that contributed to ambient $PM_{2.5}$ levels in southwest Detroit. The preliminary PMF results indicates that six major sources including coal/secondary sulfate aerosol, motor vehicle/urban road dust, municipal waste incinerators, oil combustion/refineries, sewage sludge incinerators and iron/steel manufacturing contributed to the observed ambient $PM_{2.5}$ mass in southwest Detroit during the summer campaigns. Apportionment of the mass contributions among the resolved sources will be completed next.

Toxicological Results

Telemetry data (heart rate and heart rate variability) analyses for Season 1 are still underway.

Site 1, Season 2

Exposure Results

During this reporting period, all the chemical analyses were completed on CAPs and ambient $PM_{2.5}$ samples collected during the second field intensive (Detroit, February 11-23, 2006). These analyses included thermal-optical analysis (for organic and elemental carbon samples), cation/anion samples by ion chromatography, and trace element filter samples as well as slurry samples by inductively coupled plasma-mass spectrometry. QA and QC are being performed on the database and the data are being compiled for reporting. Table 1 shows preliminary results for the chemical composition of CAPs measured in the exposure chamber during the study period.

Table 1. Chemical composition of CAPs in the chamber during the exposure period (concentrations in $\mu g/m^3$)

	CEFs	*Mass* [a]	*OM* [b]	*EC*	*Sulfate*	*Nitrate*	*NOTE*
13-day 8-hour exposure							
2/11	59	704.0	64.5	4.9	82.4	200.3	Mass measured by TEOM
2/12	41	126.4	39.4	5.6	26.0	13.6	
2/13	41	262.2	34.1	2.3	44.3	54.2	
2/14	29	564.9	57.4	5.7	60.6	188.2	
2/15	20	234.0	47.9	8.0	16.5	45.2	
2/16	29	691.2	98.1	3.3	134.1	195.7	
2/17	36	57.9	15.9	4.7	7.6	2.0	
2/18	26	116.1	6.8	1.0	13.2	7.3	
2/19	20	202.3	23.4	3.7	24.1	31.1	
2/20	22	322.8	44.7	5.8	29.3	70.4	
2/21	20	395.4	40.8	5.4	29.2	84.3	
2/22	21	703.4	173.9	16.7	49.2	148.8	
2/23	23	400.4	115.7	6.7	18.9	77.2	
Average	**30**	**368**	**59**	**6**	**41**	**86**	

NOTE:

[a] Average of two filter samples

[b] Organic mass (OM) was estimated from organic carbon (OC) x 1.8

The aerosol nitrate mass fraction was consistently higher during winter than in summer. In contrast, aerosol sulfate concentrations were higher during summer than during winter. The

highest rates of gas-to-particle transformation occur during the summer, daytime periods when photochemistry is most active; conversely, winter rates for SO_2 conversion are approximately an order of magnitude lower than summer rates. Similar results have been observed throughout the Northeast and Midwest.

Toxicological Results

Telemetry data (heart rate and heart rate variability) analyses for Season 2 are still underway.

Conclusions

Remaining exposure and toxicological analyses for Site 1 (Detroit) are underway and expanded results will be reported in the next progress report (October 31, 2006). Preliminary results for Site 2 (Steubenville), Season 1 will also be presented during the next report.

COST STATUS

The table below summarizes the budget and expenditures to date. These costs include subcontractor costs (University of Michigan, Michigan State University).

Total federal funds authorized for this funding period	$831,182
Total outlays	$416,967
Recipient share of outlays	$114,020
Federal share of outlays	$302,947

SCHEDULE STATUS

The project is on schedule. Overall progress on the Project tasks is shown in the Table below.

Technical Progress -- 12 months

Task #	Description	Planned % completed	Actual % completed
1	Field Experiments at Site 1, Season 1	100%	100%
2	Field Experiments at Site 1, Season 2	100%	100%
3	Data Analysis for Site 1	100%	50%
4	Field Experiments at Site 2, Season 1	0%	0%
5	Field Experiments at Site 2, Season 2	0%	0%
6	Data Analysis for Site 2	0%	0%
7	Field Experiments at Site 3, Season 1	0%	0%
8	Field Experiments at Site 3, Season 2	0%	0%
9	Data Analysis for Site 3	0%	0%
10	Integrated Data Analysis for All Sites	0%	0%
11	Project management and reporting	25%	25%

SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

We successfully completed fieldwork at Site 1, Season 2. Data processing and analysis for sampling and toxicological assessment in both seasons are continuing, and fieldwork for the next study location (Steubenville) has been scheduled.

ACTUAL/ANTICIPATED PROBLEMS

The Steubenville fieldwork (Season 1) was originally scheduled for July 27-August 8, 2006. However, due to a shortage of copper wire that was required for the transformer/power drop, fieldwork was delayed by one week, to August 2 – August 14. We do not foresee any further problems or delays during the next reporting period.

TECHNOLOGY TRANSFER ACTIVITIES

No technology transfer activities were carried out during this quarter.